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INDUSTRY OUTPUT, LABOR INPUT, VALUE ADDED, AND PRODUCTIVITY ASSOCIATED WITH FOOD EXPENDITURES

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Industry Output, Labor Input, Value Added, and Productivity Associated with Food Expenditures

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IN AN ARTICLE in the July 1962 issue of this journal, Waldorf (20)[1] pointed out some of the applications of an input-output model to problems in agricultural marketing. These applications fall into two categories: (1) A descriptive transactions table which shows the relationship among various industries and (2) predictive analysis which shows the impact in various industries of changes in selected exogenous variables. Since that time few if any applications of the model to problems in agricultural marketing have been made. The major reason has been the lack of data. Until 1965, the only year for which input-output coefficients of the marketing sectors were available was 1947 (7).[2]

Carter and Heady (4) produced an abbreviated table in 1954 and Masucci (13) published 1955 data for the farm sectors. Both of these studies were largely based on data in the 1954 censuses of agriculture, manufacturing, and mining. The usefulness of these data was limited because the coefficients of direct plus indirect requirements could not be computed.

In 1965, input-output tables for 1958 were published by the Department of Commerce (17); these data have sparked new interest in input-output models as both descriptive and analytical tools. An illustration of the transactions between agriculture and other sectors of the economy (based on the Commerce table) was presented by Blaich and Herrmann (2).

Though many of the studies have been descriptive, several have been predictive in the sense of showing industry requirements for estimated future demand. The Bureau of Labor Statistics has made projections of labor requirements for 1970 under varying assumptions about the labor force and final demand (14). Almon has made projections of interindustry transactions for selected years up to 1980 (1). The business community also is interested in input-output analysis. Recently Business Week published tables showing interindustry transactions to 1980 based on work done by Almon at the University of Maryland (3).

The study reported here is primarily descriptive. It shows the total output, labor, and value added requirements of each industry so that agricultural, food processing, and trade industries could produce the output represented by civilian expenditures for farm food in 1947 and 1958. The estimates of these data are made by means of the input-output framework. From these data we can pinpoint the contributions of various industries to the 1947-58 changes in total output, labor, and value added requirements to produce the farm food. These data are then interpreted to estimate the rate of increase in labor productivity for the whole subsystem producing farm food products. This system includes farmers, their suppliers, and the industries which sell to the suppliers as well as the food manufacturing, food distribution, and transportation industries.

The general procedure was to multiply diagonal matrices of final demands by various coefficient matrices in 1947 and 1958. Diagonal elements of the final demand matrices corresponding to livestock products, other agricultural products, food and kindred products manufacturing, transportation services, and wholesale and retail trade (industries 1, 2, 14, 65, and 69)[3] contain

[1] Underscored numbers in parentheses refer to items in the References, p. 131.

[2] Leontief's tables for 1919, 1929, and 1939 (11) were not sufficiently like the 1947 table to permit meaningful comparisons in the area of agricultural marketing.

[3] The industry numbers correspond to those used by the Office of Business Economics in the Survey of Current Business (17). See table 2 for a listing of the industries to which this article pertains.

final demand entries; all other elements are zero. Final demand represents civilian expenditures for farm food in 1947 and 1958. Three coefficient matrices in each year represent gross output requirements by industry per dollar of final demand, value added requirements per dollar of final demand, and labor requirements (number of persons) per dollar of final demand. A description of the computations in matrix notation is shown in the appendix.

The first step was the computation of direct coefficient matrices for 1947 and 1958. These show for a particular industry the value of various inputs purchased directly for each dollar's worth of output produced by the industry. These coefficients are computed by dividing the cost of each input by the total output of the industry. We can call this matrix of coefficients A. The 1948 matrix is approximately the same as that published in the Survey of Current Business (17). The 1947 matrix was based on a reaggregation of the original 1947 data (7) to an 82-sector table comparable with the 1958 data. The Office of Business Economics compiled the basic data for both the 1958 and the comparable 1947 tables.

The second step was the computation of an "inverse matrix," $(I-A)^{-1}$, for each year. The coefficients in this matrix show the value of direct plus indirect output required in each industry so that a particular industry can deliver one dollar of its output to final demand. This matrix was derived from the matrix A above.

The third step was derivation of the other two coefficient matrices. Direct plus indirect labor coefficients were computed by premultiplying the inverse matrix above by a diagonal matrix of direct labor coefficients. The direct labor coefficient for each industry was the total number of persons employed in an industry divided by its value of output. The direct plus indirect labor coefficients show the number of persons required in each industry so that a particular industry can deliver $1 of its output to final demand.

Direct plus indirect value added coefficients were computed by premultiplying the inverse matrix by a diagonal matrix of direct value added coefficients. These direct coefficients were computed by dividing total value added for each industry by the corresponding output for that industry.

Each of these matrices was subsequently multiplied by a matrix of civilian expenditures for farm food.

Civilian Expenditures for Farm Food

The Economic Research Service for many years has estimated total civilian expenditures for food derived from U.S. farm products. The farm value and the total marketing "bill" associated with these expenditures also have been estimated. These indicate how much the agricultural and marketing industries were contributing to the value of the consumer's purchases. A recent publication (8) presented estimates of the contribution of various marketing agencies (processors, wholesalers, retailers, etc.) to the total marketing bill.

The estimates of total civilian expenditures as published could not be applied directly to the input-output coefficients because they did not fit the necessary format. Consumers purchased farm food and related services from the following five input-output sectors:

1. Livestock products
2. Other agricultural products
14. Food and kindred products manufacturing
65. Transportation services
69. Wholesale and retail trade

The transactions tables from which the coefficient matrices are derived were quoted in producers' prices. This means that each transaction between two industries is valued at the establishment of the producer. The purchaser then buys transportation and trade services along with the product.[4] For example, in the 1958 table (17) the food manufacturing industry (industry 14) bought $16.3 billion worth of materials from livestock industry (industry 1); at the same time the food industry also purchased $0.7 billion of trade and transportation services so that the total cost of livestock products to food manufacturers was $17.0 billion. The $0.7 billion does not appear explicitly in the table but is included in the total ($2.6 and $2.4 billion) purchased from the transportation (industry 65) and trade (industry 69) industries. Since the basic data were valued at producers' prices, the estimates of civilian food expenditures used in this report also are in terms of producers' prices.

[4] See Survey of Current Business, November 1964, page 16, for fuller explanation.

Unpublished data showing the value of food shipped through various marketing channels were used to allocate expenditures among these five groups (table 1). The purchases from industries 65 and 69 represent the gross margins associated with final products that consumers purchased. Transportation, wholesale trade, and retail trade margins (including eating places) associated with eggs, fresh fruits and vegetables, and finished manufactured foods are all included in the purchases from industries 65 and 69. Transportation and assembly charges incurred between farmers and manufacturers are not included here, but are included in the manufacturer's value.

The 1947-58 increases in purchases from various sectors varied widely from the increase of 45 percent for all food. Total purchases from food manufacturing increased 50 percent while those from the livestock products group decreased 25 percent. The trade margins increased 64 percent. The increase for food manufacturing accounted for 58 percent of the total increase.

The civilian expenditures data used in this report differ in several details from personal consumption expenditures reported by OBE in the input-output tables and in the National Income Accounts (17). Food sold to medical, educational, and nonprofit organizations to be served as meals is treated by the OBE as an intermediate product purchased by those organizations for their business activities. In our civilian expenditure series we treat that food as sales to consumers through eating places. Similarly, food purchased as business expenses does not appear as personal consumption expenditures, but as an input to business (via industry 81 in the OBE tables). We include these purchases in civilian expenditures for food. These categories amounted to about 4 percent of total civilian expenditures.

Table 1.--Civilian expenditures for farm food products by producing industry, 1947 and 1958[a]

Producing industry	1947	1958
	Million dollars	
1. Livestock products.....	3,491	2,587
2. Other agricultural products.....	2,122	1,950
14. Food and kindred products manufacturing....	22,308	33,420
65. Transportation services	1,164	1,913
69. Wholesale and retail trade.....	12,853	21,127
Total.....	41,938	60,997

[a] These expenditures are valued at producers' prices in current dollars.

Personal consumption purchases in the OBE table from industries 1 and 2 include the value of food consumed on farms where grown. Civilian expenditures exclude the value of this food. Some purchases of flowers, seeds, and other greenhouse items also are included in the personal consumption expenditures from industry 2, but they are not included in civilian expenditures.

Another qualification is that the food manufacturing industry in the OBE tables includes manufactured feeds, fish, alcoholic beverages, and foods manufactured from imported products, while civilian expenditures for farm foods exclude these items. Since these products require different inputs than the farm food products, the results could be affected. However, the effect of this qualification is considered small. Alcoholic beverage production is the major item in this group.

Current Output Requirements

Expenditures for food from the five industries mentioned earlier were only the final step in a chain of transactions. For consumers to obtain this food, a certain amount of production was required in nearly every industry. These industry-by-industry outputs were computed by postmultiplying the inverse matrix, derived earlier, by the diagonal final demand matrix shown in the previous section. The result shows the output required, directly and indirectly, to enable particular industries to deliver their shares of civilian food expenditures.

1958 OUTPUT REQUIREMENTS

The food and kindred products manufacturing industry (industry 14) had the largest gross output requirements related to civilian expenditures

for farm food products in 1958 (table 2, column 6). For consumers to obtain $60,997 million worth of food, the industry had to produce $43,023 million. This is considerably above the food and kindred products component of civilian expenditures ($33,420 million) in table 1. The reason for this difference is that some of the output of the food industry was required as an input into livestock and other industries.

Some of this "extra" output was required by the other components of civilian expenditures. For example, $458 million of output by the food and kindred products industry was required to enable the livestock industry to produce its $2,587 million share of civilian expenditures. Similarly, small amounts of output were required to enable the other three industries to produce their share (read across the row for industry 14).

The second most important industry, as measured by gross output required, was wholesale and retail trade. It had to produce $25,228 million in 1958. Most of this production was needed to satisfy the $21,127 million component of civilian expenditures. However, $3,005 million in trade services were required in connection with the food and kindred products industry's share of civilian expenditures. These services enabled the food and kindred products industry and its suppliers to obtain the inputs necessary to produce those civilian expenditures. The livestock industry and its suppliers purchased $212 million in trade services associated with purchased inputs required to produce the livestock portion of civilian expenditures ($2,587 million in table 1).

The agricultural industries (1 and 2) are next in importance, though their combined output is slightly larger than that of the trade industry. The livestock industry output related to food expenditures was $16,972 million. Most of this output ($13,281 million) was associated with the manufactured food component of expenditures. It represents the returns to livestock farmers for meat animals, milk, and other products used to manufacture meat, poultry, butter, cheese, fluid milk, and other products. In addition, the livestock industry had to produce $3,315 million to enable it to fulfill its own component of civilian expenditures ($2,587 million). These expenditures included eggs and milk sold by farmers directly to consumers.

The total output requirement of the crop industry was $10,163 million. Again, most of its output was related to the food processing industry's delivery to final demand. Fruits and vegetables for processing, wheat for flour, and soybeans used for oil in shortening all represent crop inputs. In addition, the crop industry supplied feed to the livestock industry to produce meat animals and milk, which were used by food processors. Fresh fruits and vegetables purchased by consumers are included in the $2,106 million value of output required to fulfill the crop component of civilian expenditures ($1,950 million). The crop industry also needed to produce $934 million worth of feed so that the livestock industry could produce the eggs and milk in its component of expenditures.

We can follow the path through other industries and determine the various inputs required by the industries which sell food to consumers. For example, the food manufacturing component of civilian expenditures required output of $1,506 million by the real estate and rental industry (industry 71). This represents rents paid and other real estate services. Expenditures for manufactured food also required $1,837 million of output by the business services industry (industry 73). This represented mainly advertising, though other services were involved. Another important supplier of food processors is the metal container industry. It had to produce $1,024 million worth of materials so that the food processors could produce food for consumers.

1947 OUTPUT REQUIREMENTS

The requirements by industry in 1947 can be analyzed in the same manner as for 1958. Most of the important industries in 1958 were also important in 1947 (table 3). There were some changes because of the different mix of inputs in 1947 than in 1958 and because the relative importance of the various components of civilian expenditures changed between 1947 and 1958. Perhaps the most significant factor was the existence of relatively high farm prices in 1947. Since these data are in current prices, changes in output requirements reflect changes in price levels as well as changes in technology and consumer preferences.

Table 2.--Gross output needed from selected industries to produce output represented by civilian expenditures for farm food, 1958[a]

Producing industry	Industries delivering to final demand					
	1	2	14	65	69	Total
	Million dollars					
Civilian expenditures from each industry.....	2,587	1,950	33,420	1,913	21,127	60,997
1. Livestock and livestock products.....	3,315	212	13,281	8	156	16,972
2. Other agricultural products.....	934	2,106	6,936	10	177	10,163
4. Agricultural, forestry and fishery services.....	98	83	517	1	45	744
7. Coal mining.....	5	4	117	5	43	174
8. Crude petroleum and natural gas.....	38	59	488	59	188	832
12. Maintenance and repair construction.....	74	64	771	102	427	1,438
14. Food and kindred products.....	458	38	42,153	17	357	43,023
24. Paper and allied products, except containers.....	23	17	947	16	352	1,355
25. Paperboard containers and boxes.....	13	5	731	4	119	872
26. Printing and publishing.....	29	32	687	26	477	1,251
27. Chemicals and selected chemical products.	78	144	906	19	139	1,286
31. Petroleum refining and related industries	67	107	833	108	277	1,392
35. Glass and glass products.....	6	2	442	3	41	494
39. Metal containers.....	14	4	1,024	2	16	1,060
44. Farm machinery and equipment.....	9	19	78	1	15	122
59. Motor vehicles and equipment.....	13	9	151	21	126	320
65. Transportation and warehousing.....	134	68	2,819	2,074	497	5,592
66. Communications; except radio and TV broadcasting.....	21	16	323	23	311	694
68. Electric, gas, water and sanitary services.....	44	38	720	28	637	1,467
69. Wholesale and retail trade.....	212	136	3,005	95	21,780	25,228
70. Finance and insurance.....	70	57	865	68	605	1,665
71. Real estate and rental.....	153	203	1,506	94	1,410	3,366
72. Hotels; personal and repair service, excluding auto.....	5	4	123	4	133	269
73. Business services.....	82	103	1,837	54	1,297	3,373
75. Automobile repair and services.....	19	10	358	53	227	667
77. Medical, educational services, and non-profit organizations.....	21	4	145	3	36	209
Subtotal.....	5,935	3,544	81,763	2,898	29,888	124,028
Other industries.....	321	306	7,528	414	2,667	11,236
Total.....	6,256	3,850	89,291	3,312	32,555	135,264

[a] Entry in each cell represents the output required, directly and indirectly, from the industry named in the stub, so that the industry named at the column head could deliver its share of "civilian expenditures for farm food" to consumers.

Table 3.--Gross output needed from selected industries to produce output represented by civilian expenditures for farm food, 1947[a]

Producing industry	Industries delivering to final demand					
	1	2	14	65	69	Total
	Million dollars					
Civilian expenditures from each industry.....	3,491	2,122	22,308	1,164	12,853	41,938
1. Livestock and livestock products.....	4,324	266	10,970	10	121	15,691
2. Other agricultural products.....	1,804	2,355	7,979	10	130	12,278
4. Agricultural, forestry and fishery services.....	107	86	396	0	6	595
7. Coal mining.....	15	8	156	33	62	274
8. Crude petroleum and natural gas.....	42	34	247	31	97	451
12. Maintenance and repair construction.....	128	75	588	80	232	1,103
14. Food and kindred products.....	595	49	27,782	19	223	28,668
24. Paper and allied products, except containers.....	27	12	534	11	255	839
25. Paperboard containers and boxes.....	9	3	229	3	75	319
26. Printing and publishing.....	23	11	299	14	307	654
27. Chemicals and selected chemical products.	80	78	549	12	65	784
31. Petroleum refining and related industries	80	65	464	60	178	847
35. Glass and glass products.....	9	2	182	1	19	213
39. Metal containers.....	11	2	309	2	17	341
44. Farm machinery and equipment.....	7	6	28	0	2	43
59. Motor vehicles and equipment.....	21	16	129	15	116	297
65. Transportation and warehousing.....	219	83	1,566	1,251	470	3,589
66. Communications; except radio and TV broadcasting.....	8	4	82	6	121	221
68. Electric, gas, water and sanitary services.....	29	12	265	14	202	522
69. Wholesale and retail trade.....	266	115	1,418	56	13,358	15,213
70. Finance and insurance.....	72	41	402	30	308	853
71. Real estate and rental.....	234	229	1,096	26	677	2,262
72. Hotels; personal and repair service, excluding auto.....	13	11	93	4	109	230
73. Business services.....	37	19	524	15	607	1,202
75. Automobile repair and services.....	32	23	217	18	183	473
77. Medical, educational services, and non-profit organizations.....	15	3	73	2	26	119
Subtotal.....	8,207	3,608	56,577	1,723	17,966	88,081
Other industries.....	337	216	3,371	230	1,410	5,664
Total.....	8,544	3,824	60,048	1,953	19,376	93,745

[a] Entry in each cell represents the output required, directly and indirectly, from the industry named in the stub, so that the industry named at the column head could deliver its share of "civilian expenditures for farm food" to consumers.

Current Labor Requirements

A major disadvantage of analyzing the changes in gross output requirements is the problem of price changes. The prices of products in most industries fluctuate over time in response to changes in supply, demand, and cost conditions. Not all industries are affected equally.

An additional disadvantage of comparing current dollar totals for 2 years is the change in the degree of specialization. Suppose two industries now perform essentially the same operations that formerly were performed by one industry. This change will be reflected as an increase in gross output, since the first industry now sells intermediate products to the second industry which finishes the job. No new net output is created, just an increase in transactions. An illustration is the shift to the purchase of mixed feeds by livestock producers rather than growing feed on their own farms. Formerly, all of the production was limited to the feed and livestock enterprises of a livestock farm; gross output was the sum of sales by these two enterprises. Now, crop farmers grow feed crops and sell to feed manufacturers, who sell mixed feed to the livestock farmer. Thus, a new transaction has been added, though the total net output is the same. This type of increase in gross output is reflected in the change in gross output requirements between 1947 and 1958.

Part of these problems can be overcome by estimating the total labor requirements rather than gross output requirements. Tables 4 and 5 show the number of persons required in each industry to provide the farm food purchased by civilian consumers.[5] The data on employment show which industries expanded or reduced employment. Increases and decreases in employment reflect such factors as change in output of the industry, change in output per person, change in the product mix, or change in activities involved.

[5] Ideally, the number of man-hours would have been more appropriate, but adequate data on man-hours are not available for all industries. The number of persons engaged includes all paid employees, proprietors of unincorporated businesses, and unpaid family workers. The number includes full- and part-time workers with no adjustment to full-time equivalent. The number of employees for 1958 was published by BLS (14); for 1947 special data obtained from BLS were reaggregated to conform to the 82-sector table.

The amount of labor required, directly and indirectly, in each industry was computed by postmultiplying the labor coefficient matrix derived earlier by the diagonal matrix of final demands. The result is the total number of persons required, directly and indirectly, in each industry to enable a particular industry to deliver its share of civilian expenditures for food.

About 10 million persons were required in 1958 to produce and distribute food products and the necessary supplies required for that production and distribution. The ranking of various industries according to persons engaged in 1958 was considerably different from the ranking according to gross output. The largest number of persons were engaged in the wholesale and retail trade industry. This industry needed 3,599,000 persons to produce the trade services required in the production and distribution of farm foods. Table 4 shows that civilian expenditures for trade services (associated with industry 69) required 3,107,000 persons in the trade industry. In addition, 429,000 persons were required in the trade industry so that the food processing industry and its suppliers could obtain their inputs needed to produce civilian purchases from industry 14. Some of these persons were employed by fertilizer dealers and other firms which supply farmers. Others were needed in the distribution of containers and other supplies.

A small number of persons were required in the trade industries to facilitate the production and distribution of civilian purchases from livestock, crops, and transportation industries.

The second largest number of employees were engaged in the livestock products industry (1,892,000 persons). Most of these persons (1,480,000) were involved in producing the animals, poultry, and milk used in the food processing industry. A substantial number (370,000) were engaged in producing the unmanufactured foods purchased by consumers from the livestock industry (mainly eggs).[6]

[6] The allocation of persons between crops and livestock enterprises is somewhat artificial, because farmers cannot always allocate their employees accurately among farm enterprises; in addition, the estimates of average hours worked by family members are very uncertain. For this report the proportion of man-hours worked in each enterprise, estimated by ERS, was used to allocate the number of persons.

Table 4.--Persons engaged by industry for production of output represented by civilian expenditures for farm food, 1958[a]

Producing Industry	Industry delivering to final demand					
	1	2	14	65	69	Total
	1,000 persons					
1. Livestock and livestock products	370	24	1,480	1	17	1,892
2. Other agricultural products	116	262	863	1	22	1,264
4. Agricultural, forestry and fishery services	13	11	70	--	6	100
7. Coal mining	0	0	11	0	3	14
8. Crude petroleum and natural gas	1	2	16	2	6	27
12. Maintenance and repair construction	6	5	56	8	32	107
14. Food and kindred products	13	1	1,175	--	10	1,199
24. Paper and allied products, except containers	1	1	36	1	13	52
25. Paperboard containers and boxes	1	--	33	--	5	39
26. Printing and publishing	2	2	52	2	36	94
27. Chemicals and selected chemical products	3	5	29	1	5	43
31. Petroleum refining and related industries	1	1	11	1	3	17
35. Glass and glass products	0	0	29	0	3	32
39. Metal containers	--	--	34	--	1	35
44. Farm machinery and equipment	--	1	4	--	1	6
59. Motor vehicles and equipment	--	--	4	1	3	8
65. Transportation and warehousing	11	5	224	164	39	443
66. Communications; except radio and TV Broadcasting	2	1	27	2	26	58
68. Electric, gas, water and sanitary services	1	1	22	1	20	45
69. Wholesale and retail trade	30	19	429	14	3,107	3,599
70. Finance and insurance	6	5	69	6	48	134
71. Real estate and rental	2	2	17	1	15	37
72. Hotels; personal and repair service, exc. auto	1	1	25	1	27	55
73. Business services	5	6	111	3	78	203
75. Automobile repair and services	1	1	18	3	11	34
77. Medical, educational and service organizations	3	1	22	1	5	32
Subtotal	589	357	4,867	214	3,542	9,569
Other industries	12	13	257	17	131	430
Total	601	370	5,124	231	3,673	9,999
Direct[b]	288	243	931	152	3,014	4,628
Indirect[b]	313	127	4,193	79	659	5,371

[a] Each entry represents the number of persons required, directly and indirectly, in the industry named in the stub, so that the industry named in the column head could deliver its share of civilian expenditures to consumers.

[b] Number of persons required directly in the column industry. Number of persons required indirectly in all other industries, including the indirect requirements for the column industry. The direct requirements in industry 2 for its share are 243,000 persons; indirect requirements in that industry are 262-243 = 19,000 persons; indirect requirements from other industries are 127-19 = 108,000 persons.

Table 5.--Persons engaged by industry for production of output represented by civilian expenditures for farm food, 1947[a]

Producing industry	Industry delivering to final demand					
	1	2	14	65	69	Total
	1,000 persons					
1. Livestock and livestock products	583	36	1,480	1	16	2,116
2. Other Agricultural products	435	568	1,923	2	31	2,959
4. Agricultural forestry and fishery services	14	11	53	--	1	79
7. Coal mining	2	1	22	5	9	39
8. Crude petroleum and natural gas	2	1	11	1	4	19
12. Maintenance and repair construction	15	9	68	9	27	128
14. Food and kindred products	22	2	1,021	1	8	1,054
24. Paper and allied products, except containers	2	1	40	1	19	63
25. Paperboard containers & boxes	1	--	16	--	5	22
26. Printing and publishing	3	1	35	2	37	78
27. Chemicals and selected chemical products	5	5	32	1	4	47
31. Petroleum refining and related industries	2	2	12	2	5	23
35. Glass and glass products	1	0	23	0	3	27
39. Metal containers	1	--	21	--	1	23
44. Farm machinery & equipment	--	1	3	--	--	4
59. Motor vehicles and equipment	1	1	8	1	8	19
65. Transportation and warehousing	30	12	217	173	65	497
66. Communications; except radio and TV broadcasting	1	1	15	1	22	40
68. Electric, gas, water and sanitary services	2	1	16	1	12	32
69. Wholesale and retail trade	54	23	285	11	2,692	3,065
70. Finance and insurance	9	5	49	3	37	103
71. Real estate and rental	6	5	26	1	16	54
72. Hotels; personal and repair service, exc. auto	5	4	31	1	37	78
73. Business services	3	1	36	1	42	83
75. Automobile repair and services	7	5	49	4	41	106
77. Medical, educational and service organizations	7	1	35	1	13	57
Subtotal	1,213	697	5,527	223	3,155	10,815
Other industries	27	20	257	20	93	417
Total	1,240	717	5,784	243	3,248	11,232
Direct[b]	471	512	820	161	2,590	4,554
Indirect[b]	769	205	4,964	82	658	6,678

[a] Each entry represents the number of persons required, directly and indirectly, in the industry named in the stub, so that the industry named in the column head could deliver its share of civilian expenditures to consumers.

[b] Number of persons required directly in the column industry. Number of persons required indirectly in all other industries, including the indirect requirements for the column industry. The direct requirements in industry 14 for its share are 820,000 persons; indirect requirements in that industry are 1,021-820 = 201,000 persons; indirect requirements from all other industries are 4,964-201 = 4,763,000 persons.

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The crops industry also ranks high in the number of persons required. Again, most of this employment is related to supplying the food processing industry. Large numbers also are needed to produce the products purchased by consumers from the crops industry. The livestock industry sales to consumers required 116,000 persons in the crops industry, mainly to produce the feed for the livestock.

The food processing industry ranked fourth in number of persons related to civilian expenditures for farm food. Thus, its importance is substantially less than it was, with respect to gross output where it ranked first.

In 1947 the food production and marketing subsystem required 11,232,000 persons to produce and distribute civilian expenditures for farm food. The trade industry required the largest number of persons, but the total was less than in 1958. The crops industry was the second largest and the livestock industry was third. Both of these industries required more persons in 1947 than in 1958. The food processing industry ranked fourth in 1947, the same as in 1958; the number of persons was less than in 1958.

Changes in labor requirements between 1947 and 1958 are surprising. While the value of total civilian expenditures for food increased 45 percent, the number of persons engaged decreased by 1,233,000 persons or 11 percent. The total man-hours required declined even more because the man-hours worked per person generally declined between 1947 and 1958, especially in the trade industries (9). The decrease in persons required was the net result of increases in some industries and decreases in other industries. The trade industry had the largest increase. The number of persons was 17 percent higher in 1958 than in 1947. Most of this increase occurred in the requirements related to civilian expenditures for trade services associated with the finished food products. Part of this increase was caused by an increase in the proportion of part-time employees.

The largest percentage increase (51 percent) in the trade industry was related to the trade services purchased by food processors and agricultural industries. These services were associated with inputs to the food processing industry and with purchased inputs into agriculture. This large increase is similar to the large percentage increase in gross output shown in tables 2 and 3.

The number of persons engaged in the food processing industry also increased substantially, but the percentage increase (14 percent) was smaller than for trade. The business services industry also increased substantially. This increase was concentrated in the food processing and trade industries; it reflects the large increase in use of advertising and other business services by these industries.

Requirements in several other industries also increased. Though some of these were large percentage increases, they were relatively minor compared with the changes in numbers mentioned above. All of the industries with increased requirements represented a total of 957,000 more persons in 1958 than in 1947.

These increases were more than offset by decreases in the crops and livestock industries. The crops industry employed 57 percent fewer persons in 1958 than in 1947. The major cause of the reduction was the often cited improved output per person in agriculture. The addition of machinery, equipment, pesticides, and fertilizers have all aided farmers in producing more with less labor. Changes in farm organization and a decline in the use of part time unpaid family labor also have helped reduce the number of workers required. In the livestock industry the decrease was smaller, 11 percent. Apparently opportunities for increases in productivity have been fewer than in the crops industry. In addition, the consumption of livestock products has increased considerably faster than the consumption of crop products, thus helping to retard a decrease in employment in the livestock industry. Of course livestock feed crops have replaced some of the human food crops, but output per person in production of feed crops generally is greater than in production of food crops.

Fewer persons were required in several other industries, but most of these decreases were small compared with the decreases in livestock and crops. All industries with a reduction in employment requirements represented 2,109,000 fewer persons in 1958 than in 1947; 1,919,000 of these were in the livestock and crops industries. The net result of increases and decreases was a decrease of 1,233,000 persons.

Value Added Requirements

Total civilian expenditures for food are the sum of the pieces of value added by each industry.[7] Value added by each industry was computed by post-multiplying the total (direct plus indirect) value added coefficient matrix, by the final demand diagonal matrix (see p. 114 and appendix). The result is the value added requirements in each industry (directly and indirectly) to enable a particular industry to produce its share of civilian expenditures.

The major portions of value added are contributed by the trade, food processing, agriculture, and transportation industries (table 6); these industries made up 70 percent of the total. The rest is distributed throughout the economy. For example, real estate (industry 71), business services (industry 73), paper (industries 24, 25, 26), containers (industry 39), and utilities (industry 68) all make contributions to value added in civilian expenditures.

Contributions of value added by major industries in 1947 ranked about the same as in 1958 (table 7). However, the percentage contributions were considerably different (table 9). In 1947, the value added in the two agricultural industries accounted for 29 percent of civilian expenditures. By 1958, agriculture accounted for only 18 percent. During this period the farm value declined from 46 to 35 percent of civilian expenditures.[8] The relatively greater decline in the value added percentage reflects in part the increase in inputs purchased by farmers from nonfarm sectors of the economy. It also reflects a slower increase in unit cost for agriculture than for other sectors of the economy.

The value added in the food processing industry represented 18 percent of expenditures in 1958 the same as in 1947. However, value added in the trade industry increased from 28 percent to 30 percent. Many other industries also increased in relative importance including construction repair (industry 12), paper products (industries 24, 25, 26), glass products (industry 35), metal containers (industry 39), utilities (industry 68), and business services (industry 73). A few industries declined in importance (in addition to livestock and crops), but most of the changes were small.

As a result of these data we see that total food expenditures depend not only on what happens on the farm or in the retail store. Though these sectors are important, changes in the metal containers industry or the coal mining industry also affect expenditures for food. These effects are not limited to price changes, but also include the effects of substitution among inputs. For example if the price of one type of packaging rises too fast relative to the price of another type, then firms will substitute the cheaper input for the more expensive. Another example may reflect changes in consumer tastes. Consumers ate more meat and less crop products in 1958 than they did in 1947. As a result the compositions of value added changed to reflect increases in meat-packing services, feed for livestock, fertilizer for growing feed, and many other inputs. At the same time relative decreases occurred in flour milling, food crop production, and packaging materials for these crop products.

Total Requirements--Current Plus Capital Inputs

The output, labor, and value added requirements presented earlier represent only current production requirements. They include the intermediate goods and services which are used up in current production. Capital consumption and net additions to capital stock are not included. As a result these current output requirements understate total requirements which would include the capital replacement in each industry. For the data presented earlier these capital replacements are included in the value added component. To estimate the current plus capital transactions, we need to deduct the value of capital replacement from the value added component and distribute it among the various industries from which capital plant and equipment are purchased. Unfortunately, precise estimates

[7] The value added concept used here corresponds to gross national product originating. It includes labor compensation, net interest, capital consumption allowances, indirect business taxes, profits, and income of unincorporated businesses. Total value added conceptually should equal civilian expenditures shown in table 1. Small differences occur because of the approximate computational procedure and rounding errors.

[8] Farm value is the payment to farmers for the farm products equivalent to the food products purchased by civilian consumers. It totaled $19.4 billion in 1947 and $21.4 billion in 1958. It is computed independently of the input-output data presented here.

Table 6.--Value added requirements by industry for civilian expenditures for farm food, 1958[a]

Producing industry	Industry delivering to final demand					
	1	2	14	65	69	Total
	Million dollars					
Civilian expenditures from each industry.....	2,587	1,950	33,420	1,913	21,127	60,997
1. Livestock and livestock products.....	1,136	73	4,553	3	54	5,819
2. Other agricultural products.....	472	1,064	3,505	5	90	5,136
4. Agricultural, forestry and fishery services.....	44	37	231	--	20	332
7. Coal mining.....	3	2	68	3	25	101
8 Crude petroleum and natural gas.....	24	37	300	36	115	512
12. Maintenance and repair construction.....	46	39	472	62	261	880
14. Food and kindred products.....	117	10	10,758	4	91	10,980
24. Paper and allied products, except containers.....	8	6	330	5	122	471
25. Paperboard containers and boxes.....	5	2	274	1	44	326
26. Printing and publishing.....	14	15	324	12	225	590
27. Chemicals and selected chemical products.....	30	56	350	7	54	497
31. Petroleum refining and related industries	13	21	167	22	56	279
35. Glass and glass products.....	4	1	245	1	23	274
39. Metal containers.....	5	1	344	1	5	356
44. Farm machinery and equipment.....	4	7	28	--	5	44
59. Motor vehicles and equipment.....	4	2	44	6	37	93
65. Transportation and warehousing.....	81	41	1,702	1,252	300	3,376
66. Communications; except radio and TV broadcasting.....	17	14	275	20	265	591
68. Electric, gas, water and sanitary services.....	21	19	352	14	311	717
69. Wholesale and retail trade.....	154	98	2,177	69	15,779	18,277
70. Finance and insurance.....	39	32	485	38	339	933
71. Real estate and rental.....	111	147	1,090	68	1,020	2,436
72. Hotels; personal and repair service, except auto.....	3	3	75	2	81	164
73. Business services.....	37	47	843	25	595	1,547
75. Automobile, repair and services.....	9	5	172	26	109	321
77. Medical, educational services, and non-profit organizations.....	14	3	99	2	24	142
Subtotal.....	2,415	1,782	29,263	1,684	20,050	55,194
Other industries.....	177	165	4,342	231	1,043	5,958
Total[b].....	2,592	1,947	33,605	1,915	21,093	61,152

[a] Each entry represents the value added, directly and indirectly, by the industry named in the stub to the civilian purchases of farm foods from the industry named in column head.

[b] These totals should equal civilian expenditures in line 1; the small differences are caused by the approximate method of computation and rouding errors.

Table 7.--Value added requirements by industry for civilian expenditures for farm food, 1947[a]

Producing industry	Industry delivering to final demand					
	1	2	14	65	69	Total
	Million dollars					
Civilian expenditures for food	3,491	2,122	22,308	1,164	12,853	41,938
1. Livestock and livestock products	1,254	77	3,183	3	35	4,552
2. Other agricultural products	1,087	1,419	4,809	6	78	7,399
4. Agricultural, forestry and fishery services	52	41	191	--	3	287
7. Coal mining	10	5	104	22	41	182
8. Crude petroleum and natural gas	31	25	181	23	71	331
12. Maintenance and repair construction	58	34	264	36	104	496
14. Food and kindred products	151	12	7,057	5	57	7,282
24. Paper and allied products, except containers	11	5	210	4	100	330
25. Paperboard containers and boxes	3	1	78	1	26	109
26. Printing and publishing	11	6	153	7	156	333
27. Chemicals and selected chemical products	29	29	199	4	24	285
31. Petroleum refining and related industries	15	12	87	11	34	159
35. Glass and glass products	4	1	91	1	10	107
39. Metal containers	3	1	86	--	5	95
44. Farm machinery and equipment	3	2	10	--	1	16
59. Motor vehicles and equipment	7	5	42	5	38	97
65. Transportation and warehousing	143	54	1,021	816	306	2,340
66. Communications; except radio and TV broadcasting	6	3	65	5	96	175
68. Electric, gas, water and sanitary services	15	6	134	7	102	264
69. Wholesale and retail trade	199	85	1,058	42	9,963	11,347
70. Finance and insurance	40	23	223	16	171	473
71. Real estate and rental	154	150	717	17	443	1,481
72. Hotels; personal and repair service, except auto	9	7	61	2	72	151
73. Business services	17	9	249	7	288	570
75. Automobile repair and services	19	14	131	11	110	285
77. Medical, educational service organization	10	2	48	1	18	79
Subtotal	3,341	2,028	20,452	1,052	12,352	39,225
Other industries	124	85	1,097	86	449	1,841
Total[b]	3,465	2,113	21,549	1,138	12,801	41,066

[a] Each entry represents the value added, directly and indirectly, by the industry named in the stub to the civilian purchases of farm foods from the industry named in the column head.

[b] These totals should equal civilian expenditures in line 1; the small differences are caused by the approximate method of computation and rounding errors.

Table 8.--Change in value added requirements by industry for civilian expenditures for farm food products, 1947-58

Producing industry	Industry delivering to final demand					
	1	2	14	65	69	Total
	Million dollars					
Civilian expenditures from each industry.....	-904	-172	11,112	749	8,274	19,059
1. Livestock and livestock products.....	-118	-4	1,370	0	19	1,267
2. Other agricultural products.....	-615	-355	-1,304	-1	12	-2,263
4. Agricultural, forestry and Fishery services.....	-8	-4	40	--	17	45
7. Coal mining.....	-7	-3	-36	-19	-16	-81
8. Crude petroleum and natural gas.....	-7	12	119	13	44	181
12. Maintenance and repair construction.....	-12	5	208	26	157	384
14. Food and kindred products.....	-34	-2	3,701	-1	34	3,698
24. Paper and allied products, except containers.....	-3	1	120	1	22	141
25. Paperboard containers and boxes.....	2	1	196	0	18	217
26. Printing and publishing.....	3	9	171	5	69	257
27. Chemicals and selected chemical products.	1	27	151	3	30	212
31. Petroleum refining and related industries.....	-2	9	80	11	22	120
35. Glass and glass products.....	0	0	154	0	13	167
39. Metal containers.....	2	0	258	1	0	261
44. Farm machinery and equipment.....	1	5	18	--	4	28
59. Motor vehicles and equipment.....	-3	-3	2	1	-1	-4
65. Transportation and warehousing.....	-62	-13	681	436	-6	1,036
66. Communications; except radio and TV broadcasting.....	11	11	210	15	169	416
68. Electric, gas, water and sanitary services.....	6	13	218	7	209	453
69. Wholesale and retail trade.....	-45	13	1,119	27	5,816	6,930
70. Finance and insurance.....	-1	9	262	22	168	460
71. Real estate and rental.....	-43	-3	373	51	577	955
72. Hotels; personal and repair service, except auto.....	-6	-4	14	0	9	13
73. Business services.....	20	38	594	18	307	977
75. Automobile repair and services.....	-10	-9	41	15	-1	36
77. Medical, educational services, and non-profit organizations.....	4	1	51	1	6	63
Subtotal.....	-926	-246	8,811	632	7,698	15,969
Other industries.....	53	80	3,245	145	594	4,117
Total.....	-873	-166	12,056	777	8,292	20,086

Table 9.--Distribution of value added among industries, civilian expenditures for farm food products, 1947 and 1958[a]

Producing industry	1957	1958	
	Current inputs[b]	Current inputs[b]	Total inputs[c]
	Percent		
1. Livestock and livestock products	11.1	9.5	8.4
2. Other agriculutral products	18.0	8.4	7.5
4. Agricultural, forestry and fishery services	.7	.5	.5
7. Coal mining	.5	.2	.2
8. Crude petroleum and natural gas	.8	.8	.8
11. New construction	--	--	1.8
12. Maintenance and repair construction	1.2	1.4	1.4
14. Food and kindred products	17.7	18.0	15.9
24. Paper and allied products, except containers	.8	.8	.8
25. Paperboard containers and boxes	.3	.5	.5
26. Printing and publishing	.8	1.0	1.0
27. Chemicals and selected chemical products	.7	.8	.8
31. Petroleum refining and related industries	.4	.5	.4
35. Glass and glass products	.3	.4	.4
37. Primary iron and steel manufacturing	--	.6	1.2
39. Metal containers	.2	.6	.5
44. Farm machinery and equipment	--	.1	.4
59. Motor vehicles and equipment	.2	.2	.7
65. Transportation and warehousing	5.7	5.5	5.4
66. Communications; except radio and TV broadcasting	.4	1.0	1.0
68. Electric, gas, water and sanitary services	.6	1.2	1.2
69. Wholesale and retail trade	27.6	29.9	28.0
70. Finance and insurance	1.2	1.5	1.5
71. Real estate and rental	3.6	4.0	3.9
72. Hotels; personal and repair service, exc. auto	.4	.3	.3
73. Business services	1.4	2.5	2.5
75. Automobile repair and services	.7	.5	.5
77. Medical, educational services, and nonprofit organizations	.2	.2	.2
Subtotal	95.5	90.9	87.7
Other industries	4.5	9.1	12.3
Total	100.0	100.0	100.0

[a] The distributions relate to the total of the values added by the industry named in the stub for 5 final demand categories; these categories are represented by civilian expenditures for farm foods from industries 1, 2, 14, 65, and 69.

[b] Reflects value added associated with current transactions; purchases of capital equipment and buildings are not included.

[c] Includes value added associated with all transactions, purchases of capital items as well as purchases of current expense items.

of these value added components are not available.

To obtain an approximation of these current plus capital transactions in 1958, we first obtained a matrix of total capital transactions in 1958.[9] This matrix was derived by applying percentage distributions (obtained from BLS) to the gross capital formation component of final demand published in the OBE table (4).[10] The capital transactions matrix was added to the original 1958 transactions matrix. A new direct coefficient matrix (A*) was computed. From this new matrix we computed a new inverse $(I-A^*)^{-1}$, a new labor coefficient matrix, and a new value added coefficient matrix.

Total requirements of output, labor, and value added were computed for 1958 by multiplying the new coefficient matrix by the matrix of civilian expenditures (table 10).

Total labor requirements for civilian expenditures for farm food were 11,040,000 in 1958, about 10 percent more than required on a current basis.[11] The trade and construction industries were the major contributors to the increase. Most other industries added a few thousand employees, though many of these represented substantial percentage increases. These industries included farm machinery, motor vehicles, primary iron and steel, and transportation and warehousing. The increased trade and transportation requirements represent the distribution services associated with the capital goods.

Total value added requirements also were greater than current value added requirements. Ideally the value added aggregate for current plus replacement transactions should equal the value added aggregate for current transactions. The greater value added in the total reflects two adjustments which should have been made, but were not because of the lack of data. First, capital transactions should have been limited to replacement capital, omitting net additions to stock. Second the value added for each capital consuming industry should have been reduced by the amount of the capital consumption allowance component to offset the increase in value added in capital producing industries. This was not done, so the value added includes capital consumption in the consuming industry and sales of capital goods in the producing industry.

Although the aggregate value added should be the same in both cases, the distribution of value added among various industries was different. For the current requirements presented earlier, the value added by capital consumption was allocated to the industry which used the capital. For total requirements (current plus capital replacement transactions), the capital consumption was allocated to the industry which produces the capital. For example the tractors used up in food production would be included in value added by the livestock and crops industries in the current requirements table. But in the table of current plus capital requirements, these tractors are included (conceptually) in the value added by the farm machinery industry and its supplying industries.

Values added in the agriculture and food processing industries were about the same both for current transactions and current plus capital transactions because agriculture produces almost no capital items. Significantly larger values added were required in the construction, farm machinery, iron and steel, and motor vehicles industries. All of these were producers of durable capital goods. In addition, substantially more value added was required in transportation, trade, real estate, and business service industries in order to move the capital goods from producing to consuming industries.

Output Per Person in the Food Subsystem

Labor productivity is one indicator of market performance for an industry. Several studies have analyzed output per person and output per man-hour in farming, food manufacturing, and

[9] Capital transactions were not available for 1947.

[10] These capital transactions probably overstate the actual capital replacement expenditures because most industries make net additions to capital stock. This deficiency may be less important in 1958 than in other years, because it was a recession year. A few sources of data indicate that total capital outlays in the economy were about normal in 1958. For example, straight line trends of gross private domestic nonresidential investment 1947-61 nearly intersect the actual total for 1958 (18); this seems to hold for both producer durables and structures.

[11] These new labor requirements, direct and indirect, consist of the current requirements presented earlier plus labor required in the capital producing industries.

Table 10.--Requirements for production of output represented by civilian expenditures for farm foods: Gross output, persons engaged, and value added, 1958[a]

Producing industry	Output		Persons engaged		Value added	
	Current expense	Total expense	Current expense	Total expense	Current expense	Total expense
	Million dollars		*Thousands*		*Million dollars*	
1. Livestock and livestock products	16,972	17,017	1,892	1,897	5,819	5,834
2. Other agricultural products	10,163	10,240	1,264	1,274	5,136	5,174
4. Agricultural, forestry and fishery services	744	752	100	101	332	336
7. Coal mining	174	230	14	19	101	134
8. Crude petroleum and natural gas	832	948	27	31	512	583
11. New construction	0	3,582	0	155	0	1,271
12. Maintenance and repair construction	1,438	1,552	107	116	880	950
14. Food and kindred products	43,023	43,110	1,199	1,201	10,980	11,002
24. Paper and allied products, except containers	1,355	1,522	52	58	471	529
25. Paperboard containers and boxes	872	928	39	42	326	347
26. Printing and publishing	1,251	1,412	94	106	590	667
27. Chemicals and selected chemical products	1,286	1,466	43	49	497	566
31. Petroleum refining and related industries	1,392	1,585	17	20	279	318
35. Glass and glass products	494	539	32	35	274	299
37. Primary iron and steel mfg	1,001	2,090	44	91	396	826
39. Metal containers	1,060	1,074	35	36	356	361
44. Farm machinery and equipment	122	872	6	39	44	312
59. Motor vehicles and equipment	320	1,602	8	41	93	465
65. Transportation and warehousing	5,592	6,197	443	491	3,376	3,742
66. Communications; except radio and TV broadcasting	694	813	58	68	591	692
68. Electric, gas, water and sanitary services	1,467	1,667	45	51	717	814
69. Wholesale and retail trade	25,228	26,779	3,599	3,821	18,277	19,400
70. Finance and insurance	1,665	1,867	134	151	933	1,046
71. Real estate and rental	3,366	3,705	37	40	2,436	2,681
72. Hotels; personal and repair service, exc. auto	269	310	55	64	164	189
73. Business services	3,373	3,839	203	231	1,547	1,761
75. Automobile repair and services	667	732	34	37	321	352
77. Medical, educational services, and non-profit organizations	209	228	32	35	142	155
Subtotal	125,029	136,658	9,613	10,300	55,590	60,806
Other industries	10,235	16,988	386	740	5,562	5,256
Total	135,264	153,646	9,999	11,040	61,152	66,062

[a] Each entry represents the accumulated contribution directly and indirectly by the industry named in the stub for 5 categories of consumer purchases. These categories are represented by the sales of farm food products to civilian consumers by industries 1, 2, 14, 65, 69.

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Table 11.--Indexes of output, persons engaged, and output per person, food subsystem, 1947-58

Item	Indexes (1947 = 100)		Annual increase 1947-58
	1947	1958	
		Percent	
Current value of expenditures[a]	100	145.4	--
Real output[b]	100	123.0	--
Number of persons engaged in the subsystem, current transactions[c]	100	89.0	--
Output per person	100	138.2	--
Annual increase in output per person:			
Food subsystem[d]	--	--	3.3
Food marketing[e]	--	--	2.6
Food distribution[f]	--	--	1.7
Food manufacturing[g]	--	--	2.4
Farming[h]	--	--	6.0
Private economy[h]	--	--	3.0

[a] Civilian expenditures for farm food products, see Agr. Econ. Rpt. 105 (8) for definition of the data.

[b] Civilian expenditures deflated by a specially constructed retail price index for farm foods. The index reflects increases in prices of meals eaten away from home during 1953-58; for 1947-52, meal prices are assumed to increase at the same rate as prices for food at home.

[c] The number of persons employed in all industries which are directly and indirectly involved in the production of food and associated services (see tables 4 and 5). It includes direct employment in farming, food processing, food distribution, plus the persons required indirectly in industries such as containers, paper, and fertilizer manufacturers, advertising, real estate, and trade services which support the direct industries. It excludes persons required in capital goods industries such as construction and farm machinery manufacturers.

[d] The food subsystem is the same as the definition of industries contributing to civilian expenditures for food.

[e] Includes only the net output and persons engaged directly in marketing food. Assemblers, processors, and distributors of farm food products are included. Transportation and other supporting industries are excluded. Net output here includes the value of nonfood inputs.

[f] Includes net output and persons engaged directly in wholesale food trade, retail food trade, and eating places. See (22) and (9).

[g] Includes net output of persons engaged directly in food processing (11).

[h] From BLS data on net output per person (15).

food distribution (12, 21, 22, 9). Statistics on output per man-hour for selected manufacturing and nonmanufacturing industries are available from the Bureau of Labor Statistics (16). All of these data relate to specific industries and are only partial measures of industry productivity. Thus it is difficult to relate the changes in labor productivity to changes in prices. A more complete picture is obtained if we determine changes in labor productivity for a whole subsystem.[12] If we compare the total output of food and services with the total labor input in the whole system we can judge the relative improvement in efficiency of the food production and distribution system including the proportionate influence of productivity changes in the supporting industries.

Between 1947 and 1958 the real value of total civilian expenditures for farm foods and related services increased 23 percent (table 11). The total number of persons required for the production of food decreased 11 percent. Thus output per person in the food subsystem increased 38 percent or 3.3 percent per year.

The average annual increase in output per person in the food subsystem was higher than the estimates of productivity increases in food marketing and the whole economy. The agricultural sectors contributed substantially to this higher rate of increase.

Not all of this increase can be attributed to improved technology, because the labor embodied in the capital used up is not included. If we included all persons, those required in capital producing industries as well as in current input industries, then the increase in output per person probably would be less than for current purchases only. The reason for the slower increase is the increase in capital investment per employee in many industries. This factor is especially important for the food subsystem because agricultural industries were among the outstanding examples of increases in capital per employee during 1947-58.

[12] Gossling has developed the subsystem idea in estimating productivity for the agriculture subsystem in selected years, 1919-54 (10). See also article by William Gossling and Folke Dovring (Jour. Farm Econ., May 1966).

Since the productivity in the food subsystem increased faster than the productivity in the total private economy (3.3 percent vs. 3.0 percent), we should expect prices reflected in civilian expenditures for farm food to increase less than all consumer prices. The data support this conclusion. Prices of civilian food products increased 18 percent (about 1.5 percent per year) between 1947 and 1958. Meanwhile the implicit price deflator of all personal consumption expenditures increased 28 percent (2.3 percent per year). Though the magnitudes do not match precisely and we are using single-year comparisons, the direction of change is correct. Thus we can conclude tentatively that changes in food prices generally reflected improvements in productivity during 1947-58.

References

(1) Almon, Clopper, Jr. The American economy to 1975. Harper and Row, New York, Mar. 1966.

(2) Blaich, O. P., and Louis F. Herrmann. Perspectives on farm product marketing. Agricultural Markets in Change, U.S. Dept. Agr., Agr. Econ. Rpt. 95, July 1966.

(3) Business Week. Input-output forecasts for 28 industries. McGraw-Hill, Inc., New York, Jan. 1968.

(4) Carter, Harold, and Earl Heady. An input-output analysis emphasizing regional and commodity sectors of agriculture. Iowa State Univ. Agr. Expt. Sta. Res. Bul. 469, 1959.

(5) Chenery, Hollis B., and Paul G. Clark. Interindustry economics. John Wiley and Sons, Inc., New York, 1959.

(6) Dorfman, Robert, Paul A. Samuelson, and Robert M. Solow. Linear programming and economic analysis. McGraw-Hill, Inc., New York, 1958.

(7) Evans, Duane W., and Marvin Hoffenberg. The interindustry relations study for 1947. Rev. Econ. and Statis., Vol. 34, p. 97-142, 1952.

(8) Gale, Hazen F. The farm food marketing bill and its components. U.S. Dept. Agr., Agr. Econ. Rpt. 105, 1967.
(9) Gale, Hazen F., and Thomas Van Horn. Labor productivity in food distribution. U.S. Dept. Agr., ERS-372, Feb. 1968.
(10) Gossling, William. A new economic model of structural change in U.S. agriculture and supporting industries. Unpublished Ph.D. thesis, Univ. Ill., Urbana, 1964.
(11) Leontief, W. W. The structure of the American economy, 1919-1939. Oxford Univ. Press, New York, 2d ed., 1951.
(12) Loomis, Ralph A., and Glen T. Barton. Productivity of agriculture, United States, 1870-1958. U.S. Dept. Agr., Tech. Bul. 1238, 1961.
(13) Masucci, Robert H. Dollar volume of agriculture's transactions with industry. U.S. Dept. Agr., Mktg. Res. Rpt. 375, Dec. 1959.
(14) U.S. Bureau of Labor Stastics. Projections 1970, interindustry relationships, potential demand, employment. Bul. 1536, Dec. 1966.
(15) U.S. Bureau of Labor Statistics. Handbook of labor statistics, 1967. Bul. 1555, 1967.
(16) U.S. Bureau of Labor Statistics. Output per man-hour in selected industries, 1947-66. Bul. 1572, Oct. 1967.
(17) U.S. Department of Commerce. The transactions table of the 1958 input-output study and revised direct and total requirements data. Survey of Current Business, p. 33, Sept. 1965.
(18) U.S. Department of Commerce. National income and product accounts. Suppl. to Survey of Current Business, table V-13, Aug. 1966.
(19) U.S. Department of Commerce. Survey of Current Business. April 1967.
(20) Waldorf, W. H. Input-output analysis as a tool in agricultural marketing research. Agr. Econ. Res., Vol. 14, No. 3, July 1962.
(21) Waldorf, W. H. Output per man-hour in factories processing farm food products. U.S. Dept. Agr., Tech. Bul. 1243, 1961.
(22) Waldorf, W. H., and Hazen F. Gale. Output per man-hour in distributing foods of farm origin. U.S. Dept. Agr., Tech. Bul. 1335, 1965.

Appendix

By use of diagonalized vectors (diagonal matrices), developed in Gossling (8) for the subsystem approach, the procedure outlined on pages 113-4 (and by Waldorf (20)) can be presented in matrix form as follows:

Direct requirements coefficients (82 x 82 matrix)	A
Direct plus indirect coefficients (82 x 82)	$(I-A)^{-1}$
Direct labor per dollar of gross output coefficients (82 x 82 diagonal matrix)	$\hat{L}$
Direct plus indirect labor coefficients, per dollar of delivery to final demand (82 x 82)	$\hat{L}(I-A)^{-1}$
Direct value added coefficients (82 x 82 diagonal)	$\hat{V}$
Direct plus indirect value added coefficients (82 x 82)	$\hat{V}(I-A)^{-1}$
Civilian expenditures for food products (82 x 82 diagonal, 5 positive elements, other elements are zero)	$\hat{F}$
Total output requirements (82 x 82), but with positive elements in columns corresponding to positive elements in $\hat{F}$, zeros in other columns)	$(I-A)^{-1}\hat{F}$
Total labor requirements (82 x 82, 5 positive columns)	$\hat{L}(I-A)^{-1}\hat{F}$
Total value added requirements (82 x 82, 5 positive columns)	$\hat{V}(I-A)^{-1}\hat{F}$

These represent the current requirements, excluding capital inputs; estimates were made for 1947 and 1958. A similar set of data including capital inputs was computed for 1958; replace A by A* in each formulation to estimate current

plus capital requirements. For a discussion of the theoretical framework of input-output procedures and some applications of input-output analysis see Dorfman, Samuelson, and Solow (6) and Chenery and Clark (5). Frederick Nelson of ERS has disaggregated the 1958 matrix into a 109 x 109 matrix; it contains 17 agricultural sectors, 9 food manufacturing sectors, 3 primary nonferrous metals manufacturing sectors, and 3 utility sectors in addition to other industries. The original 82 x 82 matrix contained two agricultural sectors and one each of food, nonferrous metals, and utilities. The 1947 data have not been reaggregated to a 109 x 109 matrix, though the data exist for reaggregation conformable to the 109 x 109 in 1958.